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# PICTURE IN PICTURE SYSTEM WITH A DIGITAL MEMORY FOR VCRS

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## [1] Introduction

A VCR has two sources ; a signal from the tuner and a playback signal. It is very convenient if we can monitor these signals simultaneously. As the cost of a memory (RAM) has been becoming low, digital technology can be added to a VCR to meet the need.

Conventional picture in picture (P in P) system of TV sets usually produce defective small pictures,(for example,the small picture has a joint line of two different fields) in spite of expensive static RAMs.We have developed a new P in P system for VCRs which uses a newly developed dual port memory suitable for P in P operation.

Fig.1 VCR P in P

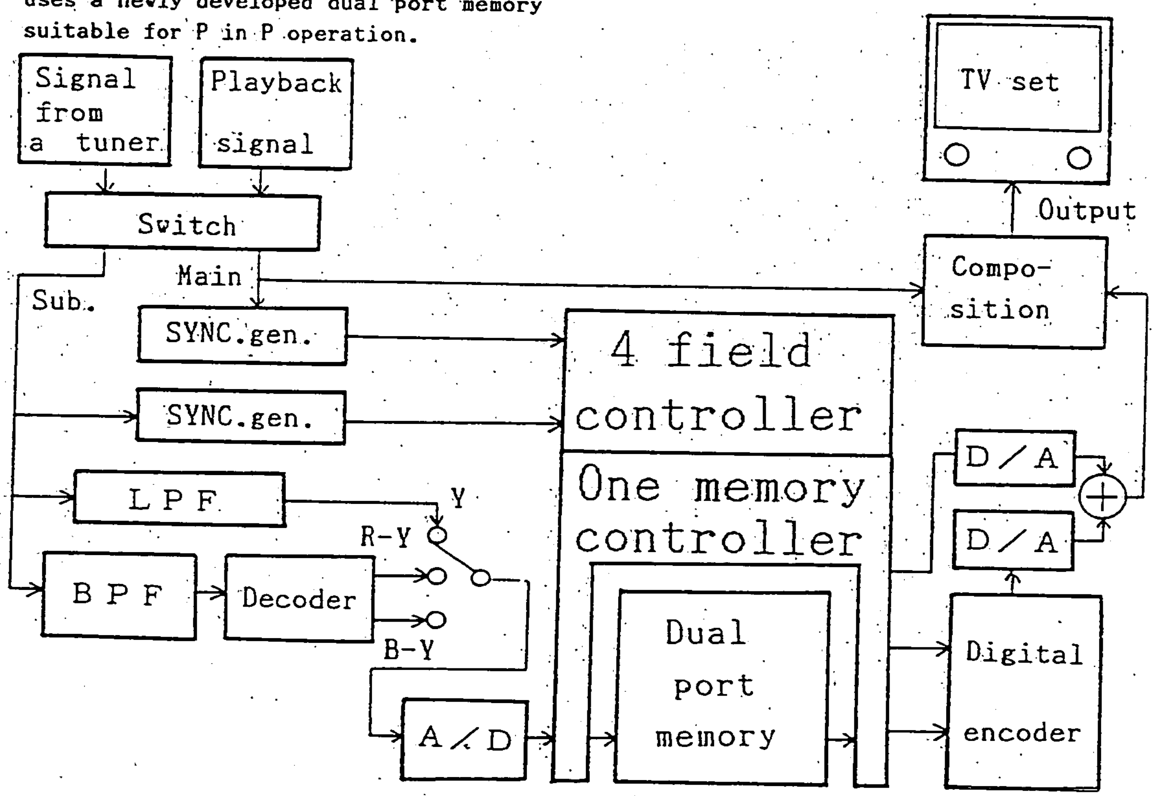


Fig.2 Block diagram of P in P

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## [2] Outline of the System

Fig.2 shows the block diagram of the newly developed P in P system.
The main operations of the system are:

(1) processing of component signals of the sub-picture.
(2) time compression of the sub-picture.
(3) composition of the main and sub-picture.

Features of the system are:

(1) fine frame synchronization using multiple field memory control.
(2) simple construction using a dual port memory.
(3) noiseless sub-picture for a trickplay signal.

## [3] Distinctive memory control

In spite of controlling four field memory areas to obtain good performance, the system has a simple structure at a low cost by using the latest dual port memory.

### (3-1) Multiple field memory control

This process gives us a fine sub-picture without a joint line or a vertical jolt which are caused by unsynchronization of the two signals.

Table 1.

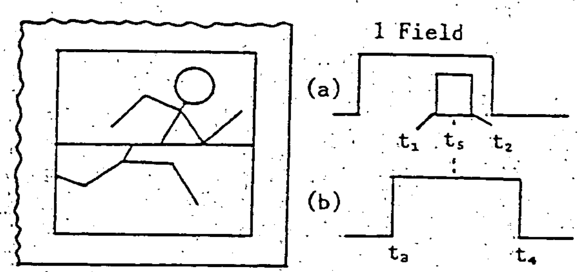
| Item | Spec. |
|---|---|
| Reduction rate | 1/3 |
| Sampling frequency | Luminance ; Input 2.4MHz<br>Output 7.2MHz<br>Crominance ; Input 0.6MHz<br>Output 1.8MHz |
| Sub-picture size | 14 $\mu$s × 64H (H : Scanning lines) |
| Sub-picture data | 6 (bit) × 256 (H) × (100+50) (dot)<br>=230 (Kbits) |
| Quantization | 6bits |

Some defective phenomena and the technique to avoid them are described here.

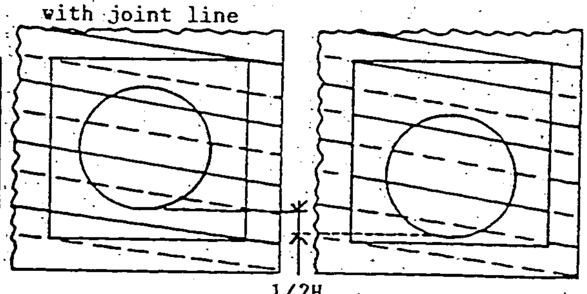
(1) A joint line

If data of a memory are read during re-writing operation, new and old data exist in the read data. The border of the new and old data results in a joint line of the sub-picture. The line is distinguishable when the movement is fast.

Fig.3 (3-1) shows a sub-picture with the joint line when data are processed using one field memory control, and Fig.3 (3-2) shows a timing chart of this process. In Fig.3 (3-2), (a) and (b) are the field switching signals of the main and sub-picture respectively. While data of a sub-picture field are written between $t_3$ and $t_4$, data of the memory are being read during $t_1$ and $t_2$. Because the sub-signal is compressed on the time axis, reading speed is faster than writing speed; the reading address outruns the writing address at $t_5$. Thus an image of a new field is displayed before $t_5$ and that of an old field is displayed after $t_5$. The result is the joint line.




(3-1) Sub-picture with joint line (3-2) Timing chart




(3-3) Match (3-4) Mismatch

Fig.3. Defective pictures

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(3-5) Practical example of a joint line

Fig.3 (3-5) shows a practical P in P picture.

(2) A vertical jolt

According to the well-known TV signal standard, a picture consists of odd and even fields for interlaced scanning. The sub-picture also comprises these two fields.

Odd/even field of the sub-picture should be agreed with that of the main picture. The mismatch would cause a vertical jolt of the sub-picture. This phenomenon is shown in Fig.3 (3-3),(3-4).

Suppose we are time-compressing a circle. Even and odd scanning lines are indicated as solid and broken lines respectively. In a case shown in Fig.3 (3-3), those lines are agrees with those of the main picture, and in the other case shown in Fig.3 (3-4), they are not. These two cases of the sub-picture have a vertical distance of 0.5 H (H : distance between two scanning lines).

Because the phase difference between the main and sub-signal is not constant, those two cases alternately appear on the sub-picture ; a vertical jolt results.

(3) 4 field memory control ( see Fig.4 )

In order to synchronize two signals smoothly and to avoid the phenomena mentioned above, 4 fields of sub-picture signal are skillfully controlled. A memory area of 256 kbits is devided by four. Two of them are assigned for even field and the other two for odd field. Written area is selected in accordance with the field type of the sub-picture, and read area is selected in accordance with the field type of the main picture. This operation avoid the vertical jolt mentioned above.

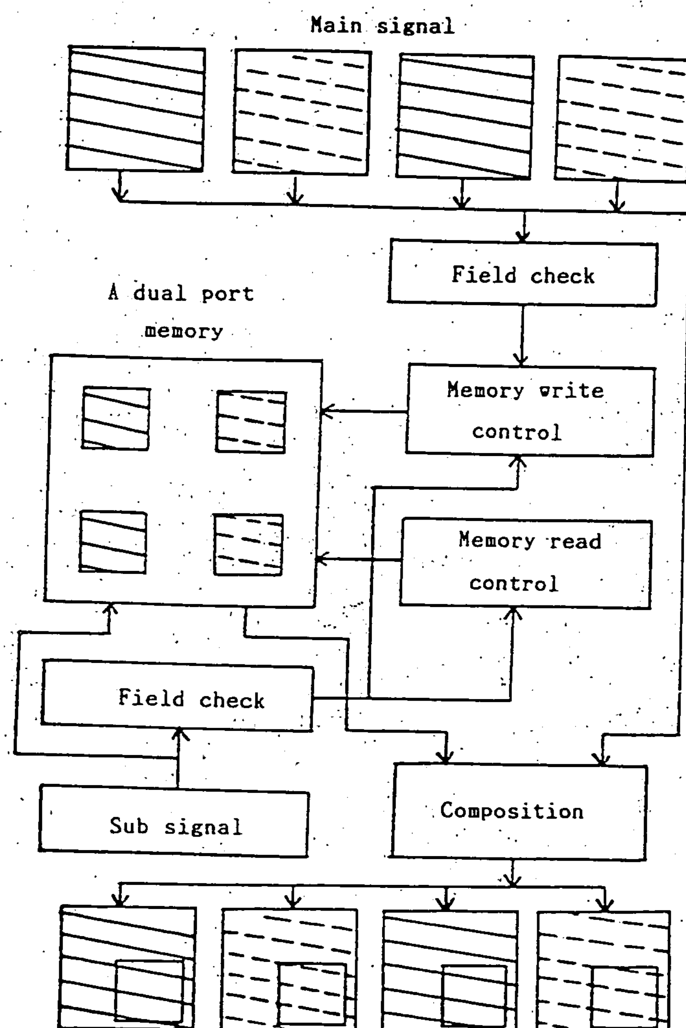


Fig.4. 4 Field memory control.

Further, because two areas are available for each field type, data of a field can be read out from eather area where data of a field has been written. This operation avoid the joint line.

The procedure of this operation is shown in Fig.4. The system includes a dual port memory and a gate array which will be described later.

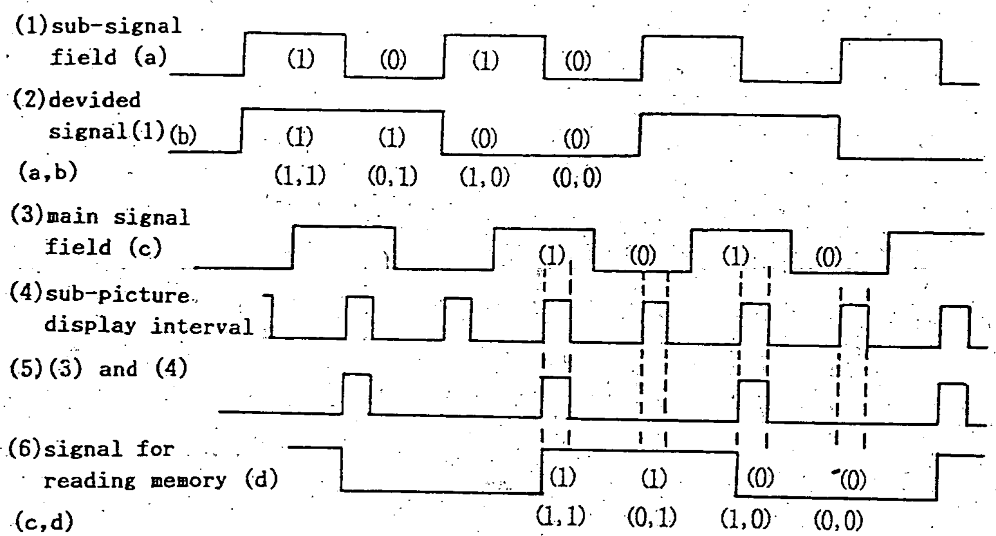


Fig.5 Timing chart of 4 field control

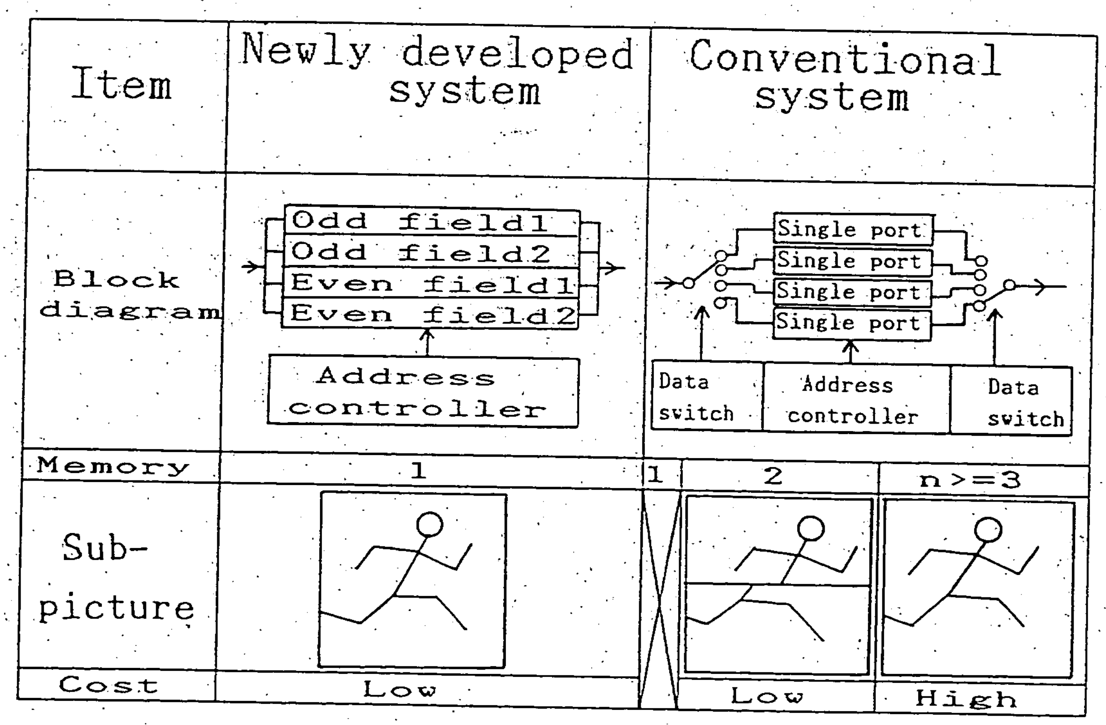


Fig.6 System comparison

Fig.5 shows a timing chart of the 4 field control. In Fig.5 (1) is the field of the sub-signal (high/low represents odd/even),and (2) is the devided signal of the signal (1). One of the four memory area is selected by the signals (1) and (2),and data of the sub-picture are written.(3) is the field of the main signal and (4) indicates intervals displaying the sub-picture.(6) is used to choose a suitable field area for reading. The signal (6) is made in the following manner : the product of the signal (3) and (4) is the signal (5). The signal (2) is sampled by the signal (5) and the inverted output is the signals (6).In reading operation the signals (3) and (6) are used to select one of the four areas. Consequently the field type of the sub-picture agrees with that of the main picture, and the joint line does not arrear because data is read out from the memory area where data are not being written.

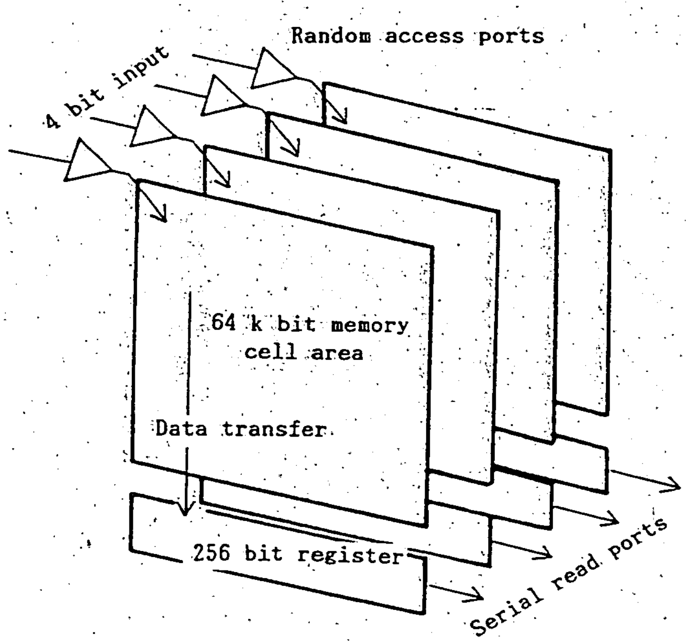


Fig.7 Dual port memory

(3-2) Application of a dual port memory

4 field control would need many memories and complicated controller if conventional memories were used. The new system employs a dual port memory which makes the system simple. We compare the new and conventional systems in Fig. 6 as an example of PinP system of a TV set.

A conventional system;

(1) needs many memories because data can not be written in and read out simultaneously.
(2) needs many switches of input and output data.

The new system;

(1) uses a memory which has large capacity and capability of simultaneous read/write operation.
(2) uses high speed serial access mode in reading operation.
(3) only controls addresses to accomplish 4 field process.

Next, we describe outline of a dual port memory adopted in this system. The memory includes a memory cell array of 256k bits (64K words x 4 bits). As well as random access mode, it has serial access mode in which data are read at very high speed from a serial port. These two modes can be asynchronously carried out at the same time except the moment when data of one row are transfered to a data register in the memory. This feature is especially advantagious in PinP operation. Minimum random write cycle and serial read cycle are 270nS and 60nS, respectively; these values are small enough to write at fsc (fsc: chroma sub-carrier frequency = 3.58MHz) and read at 3fsc. Write operation cannot be performed at the moment of data transfer. To avoid absense of data, data are written after being stored and transmitted by shift registers.

(3-3) One memory PinP

Signal processing for one memory PinP system is shown in Fig. 8. The input video signal of sub-picture is separated to luminance signal and color difference signal. These analog signals are converted to 6-bit digital signals. Due to the limitation of write cycle frequency, these two signals are sampled at different lines. This line sequential operation is suitable for a video signal becuase of strong vertical or horizontal correlation. Therefore the distance of a scanning line (between the luminance data and color difference data) has little effect. Experimental visual evaluation has proved this fact.

Since data are processed by 4 bits in the memory, 6/4 conversion is required. 6-bit luminance data are sampled at the rate of 2/3 fsc and arranged to 4-bit data. Then the data are written into the memory at the rate of fsc; one and a half time as fast as sampling rate.

Next, 4 bit data are read out from the memory at the rate of 3 fsc; three times as fast as writing rate, and rearranged to 6-bit data in the reversed manner. The rearrangement also changes the data rate from 3 fsc to 2 fsc. One third time compression is performed by this operation.

Color difference signal is processed in the same way except the rate (1/3 as fast as luminance case). The luminance data are written at skipping addresses in the memory, and the color difference data are written at the rest addresses. These data are separated when they are read out. The luminance signal is converted to the analog signal and the color difference signal is encoded by a digital encoder which will be described later.

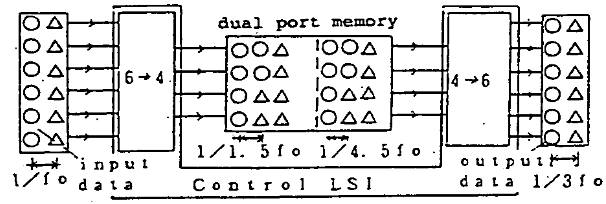


Fig.8 One memory control

[4] Other features.

(4-1) PinP in VCR trickplay

(1) Principle of noiseless trickplay

A trick playback signal of a VCR includes some noise bands because heads trace tape tracks with no signal or a lot of azimuth loss.

Conventionally, the noise has been decreased with many rotary heads for fine picture. But they could not completely remove degradation like rolling. Recently a trickplay system with digital memories has been developed. We show some example below. Principles of "Digital slow" and "Digital search" are shown in Fig. 9-1, Fig. 9-2, and Fig. 9-3. In slowmotion, the tape movement is off and on. Picture data are written into memories when the tape is stopped, and they are repeatedly read out when the tape is moving. The picture is stable without the rolling caused by start/stop of the tape. In search mode, picture data are written into memories during a half cycle of head rotation when the noiseless signal exists, and the data are read out during the other half cycle. This operation enables us to obtain noiseless pictures with relatively few heads.

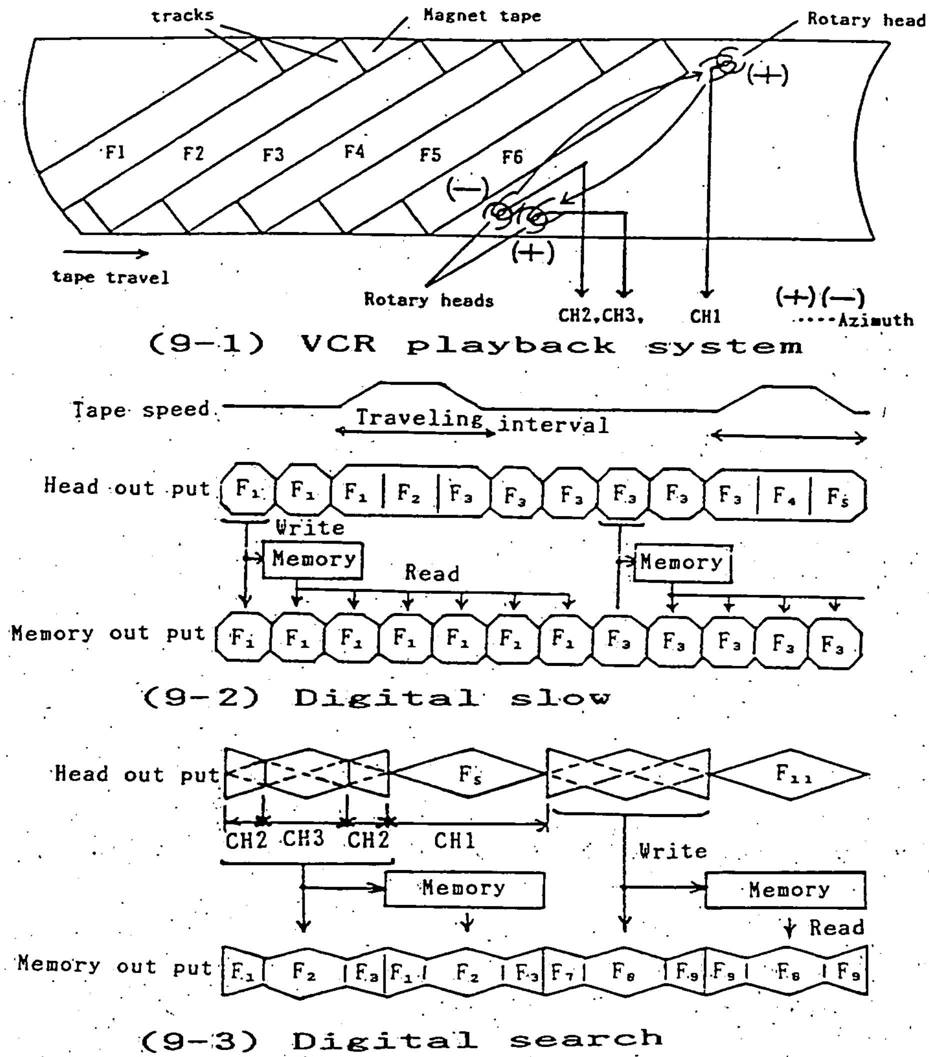


Fig.9 Principle of noiseless trick play with digital memories

(2) Application of the principle to PinP

By using the principle above, the sub-picture can be improved in trickplay mode. Another application is shown in Fig.10. This system improves the main picture using the principle above, and also displays the sub-picture.
To avoid the cost up, the A/D converter and the D/A converter are used by time sharing.

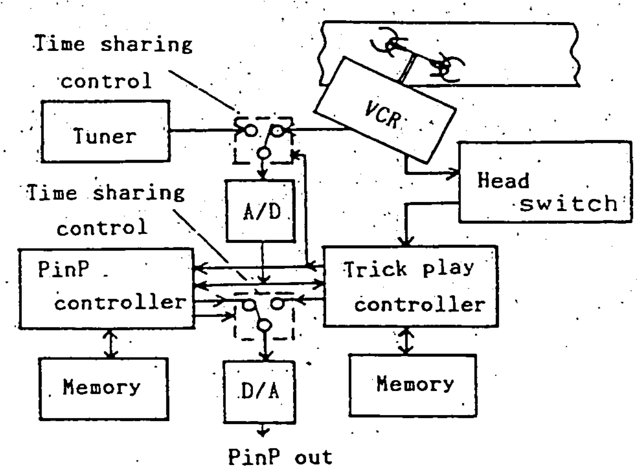


Fig.10 P in P in VCR trick play

### (4-2) Level clipper

In trickplay of a VCR, noise bands occur. If the DC level of the noise is below the pedestal level of the main signal, the noise disturbs the sync-signal of the main signal after the main and sub-signals are mixed. This causes a poor picture of unsynchronization. To avoid this, a threshold level is set which is lower than the black level of the sub-picture and higher than the sync. Threshold level of the main picture, and the sub-signal below the threshold is eliminated. The sub-picture is merged into the main picture after this process.

### (4-3) Digital encoder

To make the system small and cheap, the system employs a digital encoder,or digital quadrature modulation circuit. As is shown in Fig.13, color difference signals R-Y, B-Y and inverted signals -(R-Y), -(B-Y) are switched by the clock which is made of 4 fsc locked to the burst signal of the main picture.

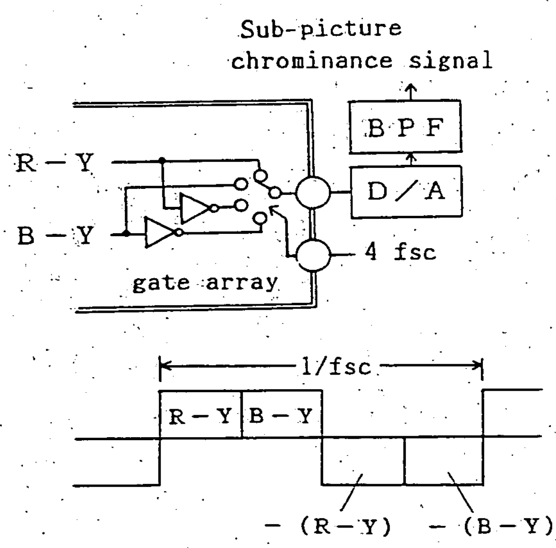


Fig.11 Digital encoder

### [5] Development of PinP control gate array

To realize a simple system with various distinctive features above at low cost, we have developed a control gate array. The gate array controls:

(1) Read/write operation of the memory.
(2) 4 feild memory control.
(3) A/D, D/A converter.
(4) Sub-picture display.
(5) Digital encoder.
(6) PinP in trickplay mode.

The gate array is 100 pin flat package with 2500 gates (see Fig. 12).

### [6] Conclusion

We have developed a new PinP system for VCRs. The features and techniques used in the system are summarized as follows:

(1) Fine sub-picture by using 4 field control.
(2) Simple structure including a dual port memory.
(3) Noiseless main/sub-picture in trickplay mode.
(4) Development of a control gate array.

### [7] Acknowledgements

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### [8] References

(1) M. Masuda et al: 'Fully Digitalized Color Picture in Picture Television System' IEEE Trans. on CE, Vol. CE-25, pp152-159 (1979).
(2) E.R.Kretzmer: 'Statics of Television Signals', Bell Syst. Tech. J.; Vol31, No.4, pp751-763(July 1952).

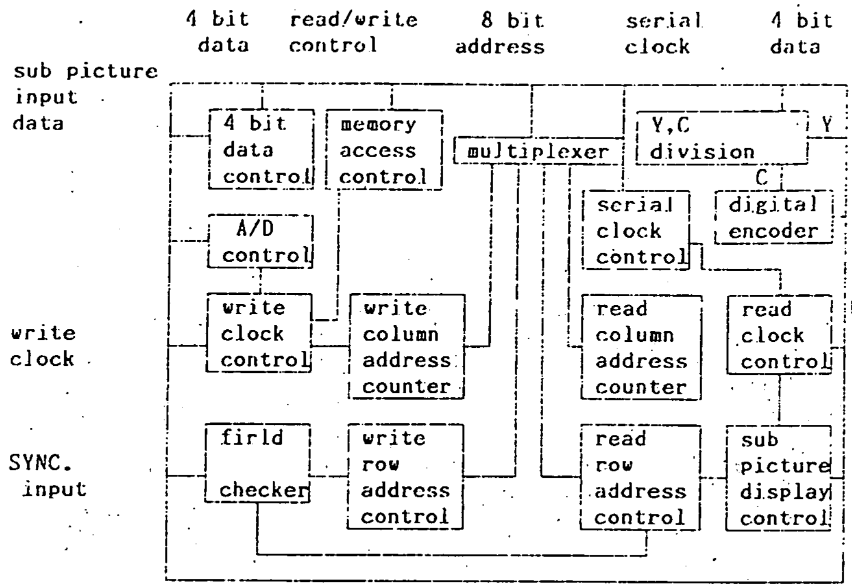


Fig.12 Control gate array